WOUND DRESSINGS

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Abstract

A hypoadherent wound dressing having a wound facing layer comprises a polymeric film e.g. a polyurethane film having a moisture vapour transmission rate of at least 500 gm<-2> 24h<-1> at 37 DEG C and at a relative humidity of 10 % to 100 % when in contact with moisture vapour, wherein the wound contacting surface of said film has an adhesion energy (as herein defined) of not greater than 30jm<-2>.

Description

WOUND DRESSINGS
This invention relates to wound dressings and to the materials used therefor.

It has been recognised that wound healing can be promoted if the wound site is allowed to remain moist and not dry out. However, poor application of wound dressings or subsequent damage to applied dressings may allow the wound tissue to dry out and, on drying, the wound exudate will adhere to the wound contacting layer of the dressing. Subsequent removal of the dressing which can be both difficult and painful may also cause wound disruption. Although these problems can be more serious with dressings made from fibrous or woven materials, significant trauma can occur with dressings comprising filmic wound contacting surfaces.

Skin substitutes have been proposed which, amongst other properties, should be capable of adhering well to the wound and of being readily removable without causing any damage to the tissue. In European Patent No. 0091128 there is disclosed an artificial skin as a synthetic wound covering consisting of a thin, tough, elastic hydrophilic membrane whose thickness does not exceed 60pm having a water permeability of 2400 to 8000gum 2 24her 1 at 370C and 60% relative humidity difference and having a modulus of elasticity of below 1034 Ncm- (1500 PSI) and an elongation at break above 500%. It is taught that such coverings will remain attached and are removed by washing with water.

The present invention seeks to avoid the disadvantages associated with known dressings by the provision of a dressing whose wound-contacting surface is hypoadherent with respect to dried exudate.

Dressings according to the present invention can be simply removed by peeling away from the healed or healing tissue with the minimum of damage and in many instances without any damage. This end has long been sought but not previously achieved in a dressing in which drying of the wound is permitted.

Accordingly there is provided a hypoadherent wound dressing having a wound facing layer comprising a polymeric film having a moisture vapour transmission rate of at least 500gsm 24h-1 at 370C and at a relative humidity difference of 10% to 100% when in contact with moisture vapour, and wherein the wound contacting surface of said film has an adhesion energy (as herein defined) of not greater than 30jim 2
As used herein the adhesion energy defines the adhesion between the film and a gelatin substrate. The adhesion energy (also called "peeling energy') is determined by the method described in J Clinical Materials, Vol 1 (1986) pp9-21 and is expressed as a e value in joules per square meter (jim~2) at ambient temperature (220r20C).

The desired values of zow adhesion energy can be obtained by controlling the bulk properties of the film or the nature of the wound contacting surface of the film or a combination of both.

The polymer for use in forming films in the dressing of the invention may be a polyurethane, including polyester polyurethanes, polyether polyurethane or a polyurethane urea or a polyamide such as a polyether polyamide or a polyester polyamide.

In an embodiment of the invention the film-forming polymer may be a moisture vapour permeable polyurethane, suitably a hydrophilic polyurethane, modified such that bulk properties of the film produce low mechanical hysteresis values. Additionally the wound contacting surface is preferably rendered hydrophobic.

employing a Polymer Laboratories Dynamic Mechanical
Thermal Analyser at a frequency of 1Hz in the range 500C to 1000C.

The peeling energy at temperature T can be represented by the equation

energy at the temperature where the film displays no hysterisis and s is a constant dependent upon film thickness.

Thus for any values of EO and S, obtained by modifiying the surface character of the film, there is a range of tan 6 values that must be related to adhesive peeling energies of less than 30jm-2.

Suitable hydrophilic polyurethanes for use in the invention may have a water content in the hydrated state of up to about 50%, more aptly 10 to 40% water, preferably between 15 to 35% water and more preferably 20 to 30% water (% water calculated on the weight of water in the polymer having been immersed in water at 200C)
The films employed in the dressings of the invention are further characterised in that they are moisture vapour permeable, and possess moisture vapour transmission rates (MVTR) of at least 500qm 2, typically from 500 to 6000gm- 24hr- at 37 C and a relative humidity difference of 100% to 10% when in contact with moisture vapour. Aptly, the films will have MVTR's in excess of 700gm-2, more aptly greater than 1100gm2. Preferred films will have MVTR'S of greater than 1500 gum 2 Moisture vapour transmission rates can suitably be determined by the Payne Cup Test
Method, which test method is described in European
Patent No. 046071.

Aptly the films employed for the dressings of the invention will be from 15 to 80 microns thick, more usually from 20 to 60 microns and will preferably be from 25 to 50 microns thick.

Obtaining low hysteresis in a urethane rubber is not normally difficult. It is sufficient to ensure that the hard segments of the molecules segregate to form hard domains, which act as cross-links and provide low hysteresis at temperatures sufficiently above the glass transition (Tg). The difficulty arises when the film is required to have high MVP. This in itself can be readily achieved by utilizing hydrophilic soft segments. But the hard segments are polar (they bond together by hydrogen bonding) and are therefore compatible with the hydrophilic soft segments of the molecules. Consequently segregation to form well-defined hard domains does not occur. Rather phase mixing takes place and the elastomer behaves like an uncross-linked rubber, with high hysteresis above T
We have found that hydrophilic polyurethanes which can suitably be used in the dressings of the invention include polyester or, more preferably, polyether polyurethanes or polyurethane ureas.

Polyether polyurethanes for use in this invention suitably will be random polymers containing units derived from polyols and polyisocyanates.

The ether units will be notionally derivable from alkylene diols or triols such as ethylene diol propylene or butylene diols or glycerol. Preferably the polyurethane will contain CH2 CH2 0- units together with -CH2 CH2 CH2 0-, -CH2 CH(CH3)O- OR -CH2 CH2 CH2 CH2 0-
Units. More preferably the ether units in the polyurethane will contain -CH2CH2 0- and CH2 CH(CH3)O- or -(CH2)4O- or mixtures thereof of which poly -CH2CH(CH3)O- blocks are preferred. In the preferred polyurethanes the mole ratio of poly(ethylene glycol) to poly[(prop or but)ylene glycol] derivable blocks present in the hydrophilic polyurethanes may vary from 1:1 to 1:30, more suitably from 1:2 to 1:10 and preferably from 1:2.5 to 1:4. The molecular weight of these blocks is aptly from 600 to 60000 and favourably from 900 to 4000, for example 1000 to 2000. Preferred polyols include diols such as these sold by British
Petroleam Chemicals under the trade names PEG 1500 and
PPG 1025 and trifunctional polyether polyols such
PLURACOL TP440 sold by BASF.

The hydrophilic polyurethanes for use as the film-forming polymers may contain di-isocyanate residues [illegible] 4,4'-Diphenylmethane di-isocyanate

[illegible] Cyclohexylmethane di-isocyanate (which is preferred) and 4,4'-diphenylmethyl di-isocyanate

It has been recognised that the selection of chain extender for the film-forming polymer can have an effect upon the bulk properties and hence the adhesion properties of the film. Although conventional chain extenders such as ethane diol can be employed, it is preferred to use aliphatic diols, diamines or [illegible]

butanediamine are an especially preferred class since films formed from amino extended polyurethanes tend to exhibit lower adhesion energies than those formed from diol extended polyurethanes.

The overall ratio of isocyanate groups to the total number of hydroxyl and, where present, amino groups should be about 1:1 to ensure that the isocyanate groups are fully reacted. However where film-forming polymers are produced by the prepolymer route, the prepolymers will contain unreacted isocyanate moieties for reaction with chain extending agents. The excess over stoichiometry, of unreacted isocyanate groups in such prepolymers can be upto 5:1 and will suitably be about 2:1 on a molar basis.

The adhesion energy of the filmic material forming the wound contacting layer of the dressing can be decreased further by other modifications to the composition of the film-forming polymer. In such an embodiment a film for example a hydrophilic polyurethane film which may or may not have an adhesive energy of not more than 30jim may be compounded or formulated with a non-leachable hydrophobic component.

Formulation may be effected by either copolymerising the hydrophobic component with the other polyurethane precursors or by blending or otherwise physically contacting a solution of the film forming polymer with a solution of an additive comprising a homopolymer or copolymer containing the hydrophobic component, or by other means.

Contact between the two polymeric species ie the film forming polymer and the additive may be effected either by direct mixing or by casting a solution of the hydrophobic additive polymer onto a cast solution of the film-forming polyurethane as a base film.

The adhesion energy of base films exhibiting adhesion energies of not more than about 100jml, typically less than about 70jm2 2 can be rendered hypoadherent by incorporation of a hydrophobic polymer additive either during production of the film forming polymer or by incorporation into the base film forming polymer, for example by blending prior to film formation. It is preferred to blend the additive component, for example in the form of a polymer with the base film forming polymer prior to forming the film.

Thus where the film forming polymer is modified by incorporation of a hydrophobic component prior to or during polymerisation, it is preferred that the latter component is incorporated with the other polymer precursors in an amount up to 10% by weight. When incorporated or blended with an already formed base polymer, it is preferred to employ a hydrophobic component containing polymer additive in amounts ranging from 1 to 20% of the final polymer mix or blend, preferably in amounts of from 5 to 20% by weight of the blend.

The present invention also provides polymeric compositions suitable for use as a filmic dressing comprising a blend of a hydrophilic polyurethane and a hydrophobic polymer additive in an amount of up to 20% by weight of the polymer blend. Suitably the additive is present in amounts of greater than 5 by weight of the polymer blend.

In a preferred composition the hydrophilic polyurethane is a polyurethane urea. More preferably the polyurethane urea when hydrated, will contain from 5 to 50% by weight water.

The solid form of the hydrophobic component-containing additive typically has a glass transition of below 400C, thereby, when used in a dressing, to allow ready diffusion of water through the hydrophobic surface layer.

Preferred hydrophobic component-containing additives are siloxane polymers such as the polyalkylsiloxanes or copolymers thereof. Especially suitable siloxane polymers are those based on polydimethylsiloxane. Preferred siloxane polymers are block copolymers of polydimethylsiloxane and also comprise a polyalkylene glycol such as polyethylene glycol, polypropylene glycol or more preferably a mixture of both polyethylene and polypropylene glycols.

An apt additive for blending with the base film-forming polymer is an additive block terpolymer of a polyalkylsiloxane, such as polydimethyl siloxane capped with a polyalkylene polyol such as polyethylene

glycol, and a polyurethane.

We have found that even where the hydrophobic component is copolymerised with the other film-forming polymer components or where a polymer containing the hydrophobic component is blended with a film-forming base polymer, the hydrophobic component tends to migrate to the surface of the cast polymer or blend. This migration of the non-leachable hydrophobic component causes a further reduction of the adhesion energy of films formed from the base polymer.

Dressings having a wound-facing layer of a modified polyurethane urea in accordance with the present invention have adhesion energies of less than 30jm~2 2 typically less than 20jm-2, more preferably less than l0jm2. Dressings produced from polyurethane ureas modified by the incorporation of a siloxane polymer preferably have adhesion values ranging from 30 to 7jim 2 , more preferably to as low as 3jm-2.

The polymers employed for the dressings in accordance with the invention may be prepared by conventional polymerisation techniques such as bulk solution polymerisation or reaction moulding. Likewise in producing the films for use in the manufacturing of dressings, known casting processes may be employed.

The dressings of the invention may be used as adhesive dressings, employing conventional adhesives, for example pressure sensitive adhesives, having use in medical applications. Suitable adhesives include acrylic adhesives which are described for example in UK
Patent Specification No. GB2070631 and vinyl ether based adhesives described for example in UK Patent Specification No. 1280631 (Composition 'A').

One type of adhesive dressing may comprise a single sheet of the polymeric film with a continuous or pattern spread coating of adhesive around the periphery. Thus the central, uncoated area of the dressing may be placed over a wound and the coated regions adhered to the healthy skin surrounding the wound.

In another embodiment an adhesive dressing may comprise a coating of pattern spread adhesive over the whole of the body facing surface of the film. The adhesive pattern may be in the form of dots, stripes or a net-like structure. Thus although areas of the dressing may be occluded by the adhesive, open areas of the dressing may be up to about 90% of the total surface area and typically will be between 60 and 70%.

In yet another embodiment a dressing may comprise a sheet of polymeric film having an adhesive tape adhered to the non-body facing surface of the film and overlying the edges of the film such that an adhesive coated projection extends beyond the edges of the film.

Suitable adhesive tapes for medical applications include those sold under the trademarks Hypal and Hypafix.

Other applications include use as a simple film to cover burns, bed sores etc., allowing excess exudate to leak at the edges for absorption by an absorbent dressing of larger overall area. The absorbent layer could then be changed frequently without disturbing the wound contact film. The film itself could be changed once the wound has started to heal without wound disruption or pain. Alternatively, the film could be perforated to allow excess exudate to drain through into an absorbent coverstock. The perforations could be pinhols at infrequent intervals to reduce the effect of adhesions at these drainage points.

Dressings in accordance with the invention may be employed for covering wounds such as burns, bed sores, surgical sites or skin grafts or wounds caused by disease or mechanical injury.

Accordingly skin lesions on animal bodies may be treated by the application of a dressing in accordance with the present invention.

The dressings of the invention may be packaged and sterilized in accordance with
procedures, for example by ethylene oxide sterilization.

The following examples

Example 1

A base film composition of a linear polyurethane-urea was produced by polymerising:
Polypropylene Glycol (PPG 1025) - 3 moles
Polyethylene Glycol (PEG 1500) - 1 mole 1,4-Diamino Butane - 6 moles
Hexamethylene Diisocyanate (Desmodur W) - 10.46 moles in a mixture of dichloromethane and t-butanol and in the presence of di-n-butyltindilaurate (T12) as a catalyst.

An additive block terpolymer was prepared by the bulk polymerisation of the following components:
Polydimethylsiloxane/PEG Block Copolymer Diol (Petrarch Siloxane Diol - MW1970)
Butane 1,4 Diol - 0.015 mole
Desmodur W - 0.035 mole T12 Catalyst - 0.050 mole
The film was prepared by addition of solution of the addition polymer in CH2Cl2/IMS (5:4vv) to make a 25% solution and mixing this with the solution of the base polymer in CH2Cl2/t-butanol to give a level of 8% terpolymer. The mixture was then cast onto release paper and dried to give a film.

The film was applied to a gelatin model as a unitary film dressing and when tested according to the method described in J Clinical Materials, Vol 1 exhibited an adhesion energy of less than 20jim 2
Examples 2-8
Solutions of polymer precursors in a mixture of dichloromethane/t-butanol were made up comprising polyethylene glycol (PEG 1500), polypropylene glycol (PPG 1025), butane diol, Desmodur W and monohydroxy-terminated polydimethyl/siloxane (PDMS) with a m wt of either 9500 or 5900. The amounts of the glycols were kept constant at 3 and 1 moles respectively whilst the amount of siloxane was varied as shown in the table. The amounts of butane diol and
Desmodur W were adjusted to maintain the overall NCO/OH ratio at 1.1:1.0.

The reactants were polymerised in the presence of di-n-butyltindilaurate catalyst. The polymer solution was then cast onto release paper and dried to give a film.

Samples of the film, intended as a unitary single film wound dressing were applied to a gelatin model and tested to determine adhesion energy according to the method described in J Clinical Materials, Vol 1 (1986) pp9-21. The adhesion energies are also shown in the following table.

Examples 2 and 6 are given for comparison purposes only.

Example No PDMS Amount Adhesion Energy
(mwt) %wt jam 2 (Average)
2 9500 0 45
3 9500 0.1 25
4 9500 1.0 22
5 9500 5.0 10
6 5900 0 45
7 5900 0.1 29
8 5900 1.0 25
9 5900 5.0 14
Example 10
A film-forming polymer containing siloxane hydrophobic components was prepared by admixing and reacting 15.90gm of PEG 1500 (MWt-1565), 29.61gm of PPG 1025 (MWt 987), 0.22gm of Pluracol 440 (Triol of
MWt-490) 390gm of monohydroxyhexylpolydimethyl siloxane (MWt - 13000) and 31.4gm of Desmodur W and heating the reaction mixture for 2 hours at 900C in the presence of T12 catalyst to obtain a homogeneous prepolymer.

[illegible] dissolved in 100ml dichloromethane. Whilst the temperature of the

A highly viscous polymer solution was obtained having a solids [illegible] onto silicone coated release paper, at a coating weight of 40gsm. After annealing at 600C for 4 hours the gelatin peel test was carried out to give the following values.

Bottom surface - 23jm-2
The concentrations of polysiloxane and triol residues in the polymer were 4.52 and 0.26% w/w respectively.

Example 11
The procedure of Example 10 was repeated except that the ratios of the precursors were changed to increase the triol residue content to 2.12% w/w.

The amounts of reactants were as follows.

Desmodure W 30.89
Pluracol TP440 1.85
PDMS-OH 3.90
PEG 1500 16.80
PPG 1025 29.61 1,4 diaminobutane 5.25 e values for the cast film were as follows.

Top surface - l3jm 2
Bottom surface - 28jm 2
Example 12
A base film forming polymer was prepared as described in Example 1 except that Desomdur W was used in an amount of 11.67 moles.

A number of samples of the base polymer were taken and to each sample was blended 0.5, 1,5 and 10% by weight of the siloxane-containing polymer additive also described in Example 1. One of the samples was a control sample which contained no additive.

The blending was carried out by mixing the two polymers on a roller bed to obtain a homogeneous blend.

Each of the blends and the control was cast onto silicone release paper as a thin film (40 + 2gsm), air dried and annealed at 600C for 4 hours. The control, 0.5, 1 and 5% additive samples were tested on the gelatin model with the paper side of the film facing the gelatin. Further samples were aged at 550C and aged for 1, 2, 4 and 8 weeks respectively. The e values for each blend, initially and after ageing are shown in the following table.

% Additive # value jm- after ageing (weeks)
Initially 1 2 4 8
Control 16 22 22 24 24
0.5 14 12 12 14
1.0 10 10 10 11
5.0 4 6 6 5 6

Further samples of each blend were packaged and subjected to an ethylene oxide sterilisation cycle conventionally used for sterilising dressings. The e values after sterilisation are reported below.

0.5 10 13
1.0 14 9
5.0 7 4

Example 13
The procedure of Example 12 was repeated except that the chain extender employed for polyurethane base film was 1,2 diamino ethane instead of 1,4 diamino butane. Blends containing 5 and 10% by weight additive were prepared, cast into films, annealed and tested.

The e value of the 5% additive film was 13.29 whilst that for the 10% additive film was 6.35. The e value for a control sample containing no additive was about 70.

Example 14
A) A film-forming polymer was produced by a one shot polymerisation process in which 18.42gm of polypropylene glycol (PPG 1025), 9.83gm of polyethylene glycol (PEG 1500) were melted, admixed with 18.51gm of Desmodur W and reacted together for 1 hour at 900C in the presence of T12 catalyst. The prepolymer was cooled to 600C after which 3.22gm of butane-l,4-diol was added with vigorous stirring until the reaction mass became solid. The solid mass was allowed to cure for a further 2 hours at 900C and then dissolved up in a mixture of industrial methylated spirit and dichloromethane to form a 25% w/v solution. The solution was cast into a film, which after drying and annealing was cut up into 7 x 7cm dressings.

B) A second film forming polymer was prepared and formed into 7 x 7cm dressings by the method described in Example 1. The amount of additive polymer in the final film was about 10% w/w.

Wound dressings were made from each of the filmic squares by adhering strips of Hypafix pressure sensitive adhesive tape to opposing edges of the film whereby the adhesive surface of the tape extended beyond the edges of the film. 4-ply gauze was placed on top of the filmic portion of the dressing and held to the reverse or top side thereof by more Hypafix tape.

5 x 5cm partial thickness wounds on flanks of pigs were covered by dressings made from polymer A (Control) and from polymer B. Six tests were made for each type of dressing.

Dressings were removed, after the elapse of preterminal periods of time.

After 2 days all wounds from which the dressings were removed appeared healthy and only minor punctuate bleeding occured. After 4 days some wound damage was caused when control dressings were removed since dried exudate adhered to the film surface. The dried exudate layer remained intact when dressings formed from polymer B were removed.

After six days elapse, some of the control films split upon attempts to remove them leaving portions of the dressing adhered to the dried wound surface.

With dressings formed from polymer B all the dressings were totally non-adherent leaving a layer of dried wound exudate intact.

Claims

CLAIMS

1 A hypoadherent wound dressing having a wound facing layer comprising a polymeric film having a moisture vapour transmission ratio of at least 500gm 2 24h-1 at 370C and at a relative humidity of 10% to 100% when in contact with moisture vapour, and wherein the wound contacting surface of said film has an adhesion energy (as herein defined) of not greater than 30jm-2.

2. A dressing as claimed in claim 1 wherein the adhesion energy is not more than 20jm-2.

3. A dressing as claimed in claim 1 or claim 2 wherein the film polymer comprises a polyurethane.

4. A dressing as claimed in claim 3 wherein the polyurethane is a hydrophilic polyurethane.

.5. A dressing as claimed in any one of the preceding claims wherein the film is formed from a blend of polymers.

6. A dressing as claimed in claim 5 wherein the blend comprises a film-forming hydrophilic polyurethane and a hydrophobic polymeric additive.

7. A dressing as claimed in claim 5 or claim 6 wherein the additive comprises a siloxane polymer.

8. A dressing as claimed in claim 7 in which the siloxane polymer is a block copolymer of polyalkyl-siloxane.

9. A dressing as claimed in claim 8 in which the block copolymer is an additive terpolymer comprising residues derived from a polyalkyl siloxane, a polyalkylene polyol, and a polyurethane.

10 A dressing as claimed in any one of claims 6 to 9 wherein the additive is present in an amount of from 5 to 20% by weight of the polymer blend.

11 A dressing as claimed in any one of claims 3 to 10 wherein the polyurethane is a polyurethane urea.

12. A dressing as claimed in claim 11 wherein the urea moieties are derived from ax alkyl amines.

13 A dressing as claimed in claim 12 wherein the amine is 1,4-diaminobutane.

14 A dressing as claimed in any one of claims 3 to 14 wherein the blend comprises a blend of a film forming base polymer, which when formed into a film has a surface energy of less than l00jm , and upto 20% of a hydrophobic polymer additive.

15 A dressing as claimed in claim 14 wherein the adhesion energy of a film of the base polymers is not more than 60jm-2.

16. A dressing as claimed in any one of the preceding claims wherein the moisture vapour transmission rate is greater than 1500gum 2 24h-1 at 370C and at a relative humidity difference of 10 to 100% when in contact with moisture vapour.

18. A dressing as claimed in claim 17 wherein the adhesive is around the periphery of the dressing

19. A dressing as claimed in claim 17 wherein the dressing is pattern spread as a discontinuous coating substantially all of the surface area of the wound facing surface

20. A dressing as claimed in claim 19 wherein upto 90% of the surface area of the wound facing surface is free from adhesive.

21. A polymeric composition for use in filmic dressings according to any one of the preceeding claims comprising a blend of a hydrophilic polyurethane and a compatible hydrophobic polymer additive which hydrophobic additive is in an amount of up to 20% by weight of the polymer blend.

22. A composition as claimed in claim 21 wherein the polyurethane is a polyurethane urea.

23. A composition as claimed in claim 21 or 22 wherein the additive is a block terpolymer of a polyalkysiloxane, a polyalkylene polyol and a polyurethane.

24. A process for the manufacture of polymeric filmic dressings wherein the film has a moisture vapour transmission rate of greater than 500gm-2 24h-1 at 370C and a relative humidity difference of from 10 to 100% when in contact with moisture vapour, which comprises forming a film from a blend as claimed in any one of claims 17 to 19.

25. Dressing packs comprising a dressing as claimed in any one of claims 1 to 20 and wrapped in packaging.

26. A dressing pack as claimed in claim 25 which is sterilized.

27. A method of treating skin lesions which comprises applying a dressing as claimed in any one of claims 1 to 20 over the lesion.

28. A method as claimed in claim 27 wherein the dressing is adhered to healthy skin around the lesion.